A Study on Evaluation Model and Role of Government and Non-government Organizations of Robot Industry Cluster in Convergence Industry Environments

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Abstract
This study was designed to investigate the role of the government and non-government organizations in economic development that occurs due to the formation of regional clusters in the robot industry under convergence industry environments, which characterize today's global industrial environment. Towards this end, a case study was conducted with a robot industry cluster in Bucheon, which is referenced in many research papers as a voluntary agglomeration zone of domestic robot companies as the primary targets, using the data from a questionnaire survey (92% response) of 50 robot companies located in Bucheon. To measure the degree of development of the robot industry in the region, five evaluation models in other regions in Korea were analyzed, and a more effective quantitative evaluation was carried out by establishing a separate comprehensive model. The research contents for the evaluation cover measurements of how companies further grow to some extent through the support of the public sector, along with companies' voluntary efforts, in addition to more than 50 items that include revenue growth and increase in employment, which could be surveyed arithmetically.

Key words:
Bucheon industry environments, Evaluation Model, Robot industry cluster, Role of government and non government

1. Introduction

The robot industry, which has not yet reached its maturity and has been undergoing various experimental processes from the perspective of technology or a market environment, must be cautiously analyzed and evaluated, and an alternative to it must be presented. In fact, the phenomenon of the slowdown in the development phase of the industry appears not only in Korea but worldwide. As in the case of Japan and the United States, which are considered advanced countries in the robot industry, a killer application that is comparable with mobile phones in the IT industry has not yet emerged.
The leading cause of the poor growth of the domestic robot industry can be found in various aspects, but essential problems arise from the question at issue of the public sector to promote private sector industries represented by an enterprise, the most basic principal of industry.

This study examines the role of the government and non-government organizations in the growth cycle of industries and the impact of industrial clusters on industry promotion, based on the overall research on the regional robot industry clusters, which serve as the foundations of the domestic robot industry. In particular, the process of the formation of industrial clusters and the performance achieved through the clusters is analyzed and evaluated with Bucheon, where the robot industry cluster has developed, as the target. Through the development of the robot industry cluster that target a specific area, policy and promotion directions as well as strategic countermeasures are presented with respect to the roles of the private and public sectors, which are divided into the central government, the regional government, local government units, non-profit research institutes and support agencies, company characteristics by size, and company roles in each area.

2. Concept and Assessment of Clusters

A look at the meaning of clusters in terms of time showed that the term cluster was first used by the first economist, Alfred Marshal. In 1890, Marshall used the term cluster for the first time, while posting the content on the extensionality of specialized industrial locations in his book titled Principles of Economics. The content analyzes the leading roles in regional development of specific industries integrated in particular areas such as the cotton fiber district of Lancashire, the pottery district formed around the Trent River and the pottery district of Sheffield, UK. Its main content deals with localization of industries, which means localization of economies in which an industry is integrated in a particular region as it becomes specialized .
The definition of a cluster varies across countries depending on the age of the researcher, and it has been conceptualized as density, relative nearness and similarity, etc. The similarity and nearness are considered to be selected exogenously according to the analysis target, and not restricted to a specific range or limited to specific

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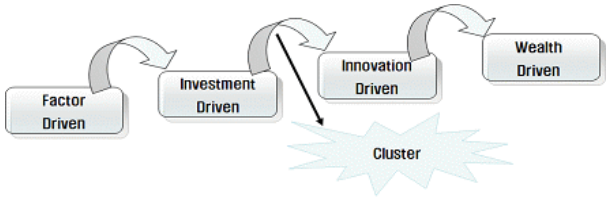
resources such as geography, technology and social characteristics.

Since the early 1990s, when the concept of a cluster was presented by Professor Porter, it has emerged as a strategic means of enhancing the competitiveness of a country or region. Porter defined a cluster as a group that is geographically concentrated into companies and agencies interrelated with common technologies and expertise in a particular field.

Figure 1. Porter's cluster concept

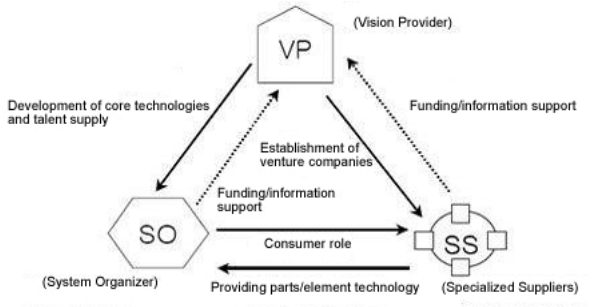


The type of cluster can be analyzed in terms of several different forms. From a most objective viewpoint, a cluster has general components that consist of the creation of a new industry, the innovation of existing industries and the innovation of the production area [3].

Table 1. Definition of clusters

Type	Characteristics
Creation of a new industry	Cluster that combines global high-tech industries with regional capabilities
Creation of existing industries	Worthwhile cluster that can incorporates new technologies
Innovation of the production area	Cluster that can absorb hi-tech solutions

Figure 2. Roles of cluster configuration subjects



Typically, a cluster consists of three subjects: a vision provider (VP), a system organizer (SO) and specialized suppliers (SSs). In general, a vision provider (VP) develops core technologies, presents directions for the development of an industry, lays the foundation for talent supply and establishes venture companies. A system organizer (SO) is in charge of product development and does so by commercializing core technologies and integrating element technology and components. Specialized suppliers (SS) refer to small and medium-sized businesses and venture enterprises that provide component and element technologies, as well as support service companies that provide financial,

To conduct a systematic and effective evaluation of the performance of the robot industry cluster in Bucheon, this study investigates and analyzes performance assessment practices in existing domestic industrial cluster policy projects to derive the appropriate evaluation framework and indicators. The domestic cluster concept was proposed in the early 1990s, which means the cluster policy has a brief history. It was not until recently that policy interest has focused on the composition or activation of clusters, but there is a relative lack of concern with the evaluation of the performance of clusters. The results of the evaluation of five domestic regional clusters were investigated, and the following were analyzed, in this order: the main features of the performance evaluation for each cluster, evaluation indicators, evaluation methods and suggested implications for the evaluation of the robot industry cluster in Bucheon, which is the core of this study.

Table 2. Targets for a case study on cluster projects

Segment	Project Name
Korea Institute for Industrial Economics & Trade	Regional industry promotion performance evaluation[5].
Korea Research Institute for Human Settlements	Plans to promote regional strategic industry clusters[6].
Corporate Management Research	Study and analysis of the properties of clusters of the industrial complex in the Jeonnam region [7].
Korea Advanced Institute of Science and Technology	Improvement and measurement of the Daedeok Innopolis performance indicators [8].
Korea Institute for Industrial Economics & Trade	Study on the establishment of evaluation systems for regional industrial policies[9].

3. Concept of Public Goods and Needs of the Public Sector and the Private Sector

To discuss the roles of the government and non-government organizations in the robot industry in Korea, it is very important to proactively review the roles of the robot industry in regions in terms of public goods. In this regard, this chapter examines the concept and characteristics of public goods and local public goods to consolidate the theoretical foundation for the public goods.

Basically, it is very difficult to clearly define or formulate the concept of public goods. In general, public goods are understood as symmetrical to private goods. Public goods [10] refer to goods the consumption of which does not reduce the consumption of such goods by others, and that are supplied to ensure use with no or minimum cost and

are managed directly by the government without going through the market mechanism.

A look at the examples that best describe the characteristics of public goods reveals two characteristics: non-excludability of benefits and non-rivalry in consumption [11]. Their meanings are as follows.

Non-excludability of benefits points to a situation in which any one of the individuals involved cannot be excluded from the benefits arising from the goods once they are provided, regardless of the contributions of each individual. In other words, the first characteristic of public goods is that their consumption by any person cannot be prevented in any way, which is referred to as non-exclusiveness. In the case of private goods, those who have no money or less need for such goods can be prevented from consuming them through a tool called the market price. That is, those who are thought to be unsatisfied with the goods vis-a-vis their price in the market or who cannot afford to pay such price can be excluded.

On the other hand, non-rivalry in consumption makes 'exclusion' inefficient. Among the goods characterized by non-rivalry are information and new technology goods, with which exclusion is possible. However, if goods that can be enjoyed by several people at no additional cost are limited to only a few people and their consumption by other people is prohibited, they will have socially inefficient results. Along these lines, cases occur in which the exclusion is not made for social efficiency even though it is possible technically, and the good's non-exclusiveness eventually makes it difficult for the market to provide. While in the case of private goods, an increase in the amount that a person consumes leads to the gradual reduction of the remaining amount, which makes the good rare, with public goods, the amount does not change.

Industrial policies in most industrialized countries are formulated by a mix of the public sector and the private sector. In industrial policies formulated by the public sector, the service principal becomes the government. That is, financial resources come from the government budget, and service delivery and operation of agencies are performed by civil servants. On the other hand, in industrial policies formulated by the private sector, the subject of the service is a civilian, and the funding and operation are performed without the involvement of the government. However, in modern society, the pure form of public-sector or private-sector-made industrial policies is rare, and most of such policies are formulated jointly by the government and non-government organizations.

There have been many discussions on whether the public or the private sector is the desirable provider of industrial policies, as they have their respective advantages and disadvantages in terms of the efficient allocation of social resources, equality and freedom.

In the public sector, the owner of institutions that provide services is the government, financial resources come from the government budget, and the service institutions are operated by civil servants. The most important reason why services are provided primarily in the public sector is the so-called 'market failure.' The reason for the services to be provided by the public sector is explained using such grounds as the nature of public goods, incomplete information of service providers or consumers, problem of 'adverse selection', phenomenon of 'moral hazard', interdependent probability and economies of scale.

In the private sector, the owner of the company that provides the service is a civilian, funding comes from non-government organizations, the company is operated by civilians, there are no tax benefits from the government due to the absence of regulations from the government, and the company is not accountable to the government. A service should be provided by the private sector based on the concept of 'government failure' or 'non-market failure.' These discussions on public-sector and private-sector formulation of industrial policies are based on the assumption of their pure forms. In the past, there were many pure forms of the public and private sectors, but these forms are rarely found today. In addition, since the mix of the public sector and the private sector is now dominant, the direct application of the preceding discussion is limited.

4. Performance Evaluation and Analysis of the Robot Industry Cluster in Bucheon

To strategically promote the robot industry in Bucheon, its relationship with the industrial features in Bucheon was analyzed. The analysis revealed the following facts. First, the robot industry is an industrial field that facilitates the establishment of new high-tech industries and market creation through linkages with existing cultural content industries and the precision electronics, electrical machinery and parts industries. Second, many element technologies have already been secured in Bucheon, and the robot industry is the most promising area of technology development and industrialization through short-term intensive investments. Finally, the robot industry in Bucheon can be characterized as a strategic industry of the service robot industry that can fuse two industries into one to foster the precision parts and cultural content industries and develop them into knowledge-based high-tech industries.

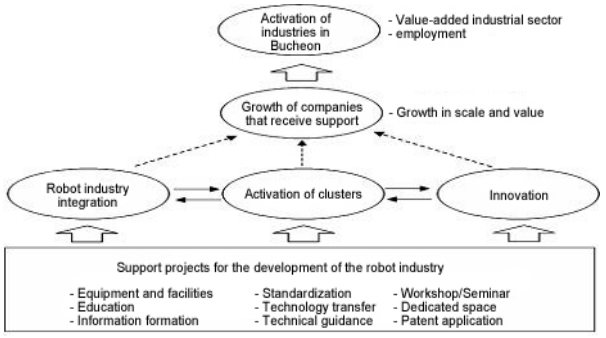
Bucheon City, to promote its robot industry, constructed a Techno Park in Samseong-dong and Yakdae-dong from November 1997 to October 2000; integrated 209 electronic information and communications companies, 51 machinery industry businesses and 30 mold industry companies; and promoted the industries that serve as foundations of industrial technology in Building 203, Techno Park in Yakdae-dong from July 2001 to November 2006, thereby

successfully creating there a state-of-the-art research industrial complex [12].

5. Performance Evaluation Model for the Robot Industry Cluster in Bucheon

The conceptualization of the process that starts with support for the development of the robot industry in Bucheon to its performance creation showed that the support for the robot industry development in Bucheon is being provided in the type of package, which ranges from construction/movement into the Techno Park to technology development, training of manpower and activation of exchanges. These support businesses are aimed at activating innovation through cooperation and competition by integrating robot-related businesses and support agencies in Bucheon and increasing economic/non-economic exchanges between the integrated companies. The development of the robot industry cluster in Bucheon is expected to contribute to the growth of robot-related companies and the enhancement of the robot industry's status, which should ultimately lead to industrial activation in Bucheon. This ideal performance creation process is shown in the following figure.

Figure 3. Ideal performance creation flow of support businesses for robot industry development



Based on the aforementioned performance creation flow, the development status of the robot industry in Bucheon was evaluated. The promotion of the robot industry in Bucheon started with the artificial integration of robot-related companies and the support business stimulation of the activation and innovation of the clusters. Accordingly, the degree of the robot industry integration, the level of cluster activation, the investments for innovations and the realization of such innovations serve as important elements of the evaluation of the effects of the foundation that has been formed by such support businesses for the growth of robot-related companies in Bucheon.

Finally, it is clear that an evaluation of the contribution of robot industry development to industry activation in Bucheon is needed in the light of the current sale of the robot industry, but it is considered important to forecast the degree of such contribution in the future. Based on the flow of the performance creation, the following agenda for the review of business performance with respect to support for robot industry development can be established.

Table 3. Topics on the agenda for the evaluation of the performance of the robot industry

o Were robot-related companies integrated successfully?
o Is the horizontal networking for cooperative competition between robot-related companies being done well?
o Was the innovation implemented actively based on the robot-related support businesses and networking?
o Did the robot-related companies that operate in Bucheon achieve superior growth compared to companies outside Bucheon?
o How much has the robot industry in Bucheon contributed to the economic revitalization of Bucheon?
o If the preceding questions had negative consequences, why was that so?

To deduce the performance evaluation index for Bucheon robot industry support projects, a performance evaluation index pool was made in accordance with the basic directions for R&D performance evaluation, and the business characteristics by phase of the support businesses (input-output-results performance) were considered. The results are shown in Table 5 and Table 6.

Table 4. Performance evaluation index by IPO process

Segment	Performance Evaluation Index Pool		
	Scientific and Technological Innovation Capability Assessment	**Korea Institute for Robot Industry Advancement**	**BIPF Performance Evaluation Index**
Basic directions for the performance evaluation	Resources Activities Networks Environment Performance	General status of robot companies Status of companies specializing in robots Production and delivery results R&D and Imports and exports intellectual property Robot-related workforce Status of equipment and investments R&D and intellectual property Robot-related workforce Status of equipment and investments	Level of integration of robot-related industries Activation of clusters Innovation Growth of companies that receive support Revitalization of the local economy
Consideration of the evaluation items by business promotion phase			
Evaluation that considers the characteristics by business			
Long-term technical and economic performance evaluation			

Based on the use of these indicators, the performance-generating mechanism of ripple effects and support systems by theme for the evaluation of the performance of the robot industry in Bucheon can be illustrated as follows.

Table 5. Performance evaluation causal configuration of the robot industry in Bucheon

Perspective	Performance-generating Causal Map (Strategic Map)
Performance (Ripple effect)	Import substitutions effect, revitalization of the local economy
Customers (Performance of beneficiary enterprises)	Customer satisfaction, other outcomes, technical performance, economic performance
Internal processes (Performance of support businesses)	Participation in Robot World, operation of Bucheon Robo Park, fostering of a robot-specialized workforce, support for the development of robot products and parts, forum and technical exchanges, operation of research equipment
Resources and support infrastructure	Level of robot industry integration, committed workforce, reserve equipment, budget, technical information

6. Results of the Evaluation of the Performance of the Robot Industry Cluster in Bucheon

To analyze the support performance of the robot industry in Bucheon, a full enumeration survey of the companies that received support was conducted for 30 days in 2011 with respect to the general status of the companies (5), the resources and infrastructure (3), the level of satisfaction with support businesses (3), the performance of beneficiary enterprises (6) and the suggestions and complaints (3). For the content of the detailed survey design, 75 samples were used, with the support beneficiary enterprises of the Bucheon Industry Promotion Foundation in 2011 as the primary targets, and the full enumeration was performed by professional interviewers.

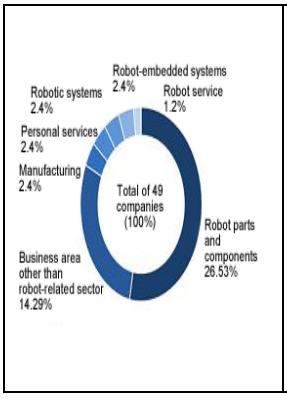
Of the 49 companies, 35 were robot-related, and they accounted for 73% of the total sales. A further investigation showed that most (26, or 53%) of the companies specialized in robot parts and components , followed by companies that manufactured robots, personal service robots, robotic systems and two robot-embedding companies (4%) and one robot service company (2%).

As for the sizes of the 36 robot-related companies, 22 (61%) were medium–sized, 13 (36%) were small and one (3%) was large. Of the 22 medium-sized companies, 17 specialized in robot parts and components and two manufactured robots for personal services. Of the 13 small companies, nine manufactured robot parts and components. The lone large company produced robots for the manufacturing industry.

Table 6. Survey overview and questionnaire survey items

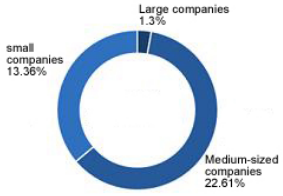
Survey Design		Content of Questionnaire Survey	
Survey targets	Beneficiary enterprises of the 2011 BIPF Support Project	Part 1. General status of the companies (5)	General information on the companies Production/delivery/sales results Robots and parts import status Status of employees and the research workforce
Number of samples	75	Part 2. Resources and infrastructure (3)	R&D investments Equipment investment results Robot industry cluster
Sampling method	Full enumeration survey	Part 3. Level of satisfaction with Support business services (3)	Satisfaction with support businesses Satisfaction with support business procedures Overall satisfaction
Research method (Gallup)	Interviews by professional interviewers Fax/email survey	Part 4. Performance of the beneficiary enterprises (6)	Productivity / Failure rate / Production cost effect Contribution to sales / Import substitution effect Intellectual property rights, etc.
Data collection tool	Structured questionnaires	Part 5. Suggestions and complaints (3)	Complaints Required equipment Other policy suggestions

Table 7. Number of robot companies based on their sales amount



Category	Number of Companies
Robot parts and components	26
Business area other than robot-related sector	14
Manufacturing	2
Personal services	2
Robotic systems	2
Robot-embedded systems	2
Robot services	1
Professional services	0

Table 8. Number of robot companies by business size

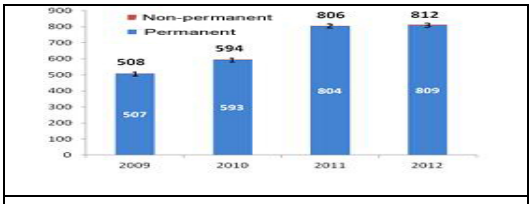


Sector (statutory type)	Number of Companies
Large companies	1
Medium-sized companies	22
Small companies	13

As of 2012, there were 812 robot industry employees from only 508 in 2009. Thus, the compound annual growth rate (CAGR) for four years (2009-2012)_was 17%. The number of robot industry employees increased most from 594 in 2010 to 806 in 2011. A closer examination of the results by part revealed that as of 2012, robot parts and components companies had the greatest number of

employees [443 (55%)], followed by the companies that produced robots for manufacturing [172 (21%)] and those that produced robots for personal services [139 (17%)].

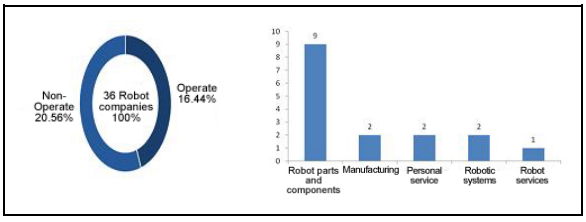
Table 9. Changes in the numbers of employees



Segment		2009	2010	2011	2012
Number of employees	Permanent	507	593	804	809
	Non-permanent	1	1	2	3
Total		508	594	806	812

Sixteen companies (44% of the total number of companies) retained/operated robot-related research institutes. A closer look at the results by area showed that nine companies specialized in robot parts and components, two manufactured personal service robots, another two produced professional service robots and one offered robot services.

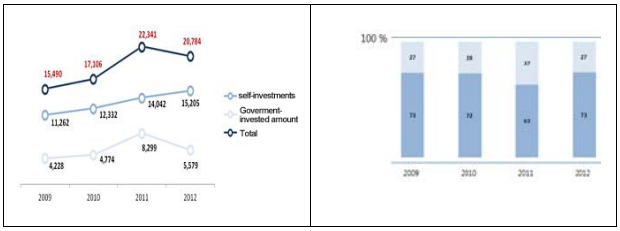
Figure 4. Status of the operation of robot-related research institutes



Operation/Non-operation

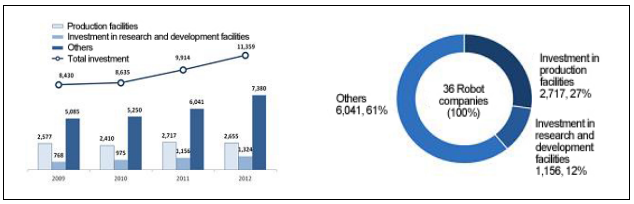
In terms of the resources and infrastructure, the R&D investment of robot companies in Bucheon has continued to increase from 15,409,000,000 won in 2009 to 22,341,000,000 won in 2011. The proportion of self-investments in the R&D investments was approximately 27-73%, which was higher than the proportion of government investments. In 2011, the proportion of government investments slightly increased to 37%.

Figure 5. Changes in R&D investments



The total investment of robot companies increased by 15% from 8,635,000,000 won in 2010 to 9,914,000,000 won in 2011, and has continued to increase since 2009. An examination of the change in the investments by purpose found that investments in other purposes had the largest proportion and showed constant growth, followed by investments in production facilities, which repeatedly increased and decreased annually, and investments in R&D facilities, which is still increasing.

Figure 6. Changes in investments by purpose



7. Suggestions on the Roles of the Public and Private Sectors in the Development of the Regional Robot Industry

The grounds for the role framework of the government and non-government organizations in the introduction and spread of the robot industry have been presented. Basically, the role of government can be said to be effective policy formulation and enforcement to represent the national interests. Accordingly, these policies should be established based on solutions to the issues and concerns about the promotion of the domestic robot industry. In addition, it is desirable for the government's policy directions to be presented based on comprehensive theories and a practical foundation, and not be limited to any theoretical framework. Meanwhile, the members of the private sector that has the most important role in the construction and spread of robots are robot supply and demand companies. The problems they are facing now are as follows. For robot supply companies, their problems arise from (1) their lack of a killer application, (2) the lack of recognition of the need for value innovation for market creation and (3) the lack of collaboration between companies. To address these problems that pertain to the unique roles of the government and non-government organizations and to promote the continuous development of the robot industry, continues efforts are needed that separate the roles of the government and the private sector, as shown in the following table.

Table 10. Roles of the government and non-government organizations in the development of the robot industry in Bucheon

Roles of the Government	Roles of Non-government Organizations
1. Establishment and adjustment of national	1. Discovery of killer applications that can lead

strategies 2. Demand creation through a pilot project 3. Support for base elements such as technology development and establishment of standards 4. Education on and promotion of public goods 5. Introduction of leading utilization systems for the public sector	in the market 2. Formulation of value innovation strategies for market creation 3. Promotion of awareness on inter-enterprise collaboration for the development of convergence technologies 4. Formulation of active investment strategies for robot demand companies

8. Conclusion

In this study, the efforts needed from the public sector, to supplement the voluntary efforts of private companies, in the development of the regional robot industry were investigated, and the qualitative and quantitative influence of these efforts on the development of the robot industry was analyzed. Based on the findings from this study, the roles of the government and non-government organizations in the future development of the robot industry were examined.

To measure the degree of development of the robot industry in the region, five evaluation models that had been promoted in the public sector in other regions in Korea were analyzed. Based on the analysis results, a more effective quantitative evaluation was performed by establishing a separate comprehensive evaluation model. The major contents of the evaluation included measurement of the company growth through the support of the public sector, in addition to voluntary efforts of companies, along with investigations on the increase in employment and sales, which arithmetically facilitated the survey.

The results of the quantitative evaluation of the degree of development of the robot industry in Bucheon showed that the industry generally developed at a very fast pace in the past decade. In terms of its sales growth, an annual average growth rate of 15% was recorded after its 74% growth in 2004. An interesting implication of this is that a group of companies that received support from the government recorded sales of 108% and an annual average growth rate of 20%, which significantly differed from the 15% average annual growth rate of the group that did not receive such support. The investigation of the amount of increase in the companies' investment in technology development showed that the group of companies that received support from the government had a 71.8% increase in R&D investments in technology development, whereas the unsupported group of companies showed only a 34.5% increase. As for the rising trend in the number of employees of robot companies, there was a 58.4% increase (annual average: 12.2%), but the group of companies that received support from the government had a 75% increase (annual average: 15%). These figures show significant differences between the two groups. A look at the rising trend of intellectual property rights, which was a critical factor of the evaluation of corporate innovation, showed that the patent share of the group of companies that received government support in the total patent ratio was 80%, which leads to the conclusion that government support has contributed greatly to companies' acquisition of intellectual property rights. In addition, the results of the investigation of the innovation cluster in terms of competitiveness showed that the cluster has a relative competitive edge of more than 10% but still lacks competitiveness in terms of the absolute scale. Based on the results that were obtained after considering all the factors (overall dominance, relative scale, absolute scale, location quotient and level of integration), the innovation cluster can be evaluated to be around Step 3, the intermediate step.

It was found that government support boosts a company's innovation investment and growth, directly enhances innovation performance such as in terms of intellectual property, and ultimately has a positive impact on the company's innovation and growth. In this regard, systematic and consistent support is needed. This study attempted to separate and propose the roles of the government and non-government organizations after synthesizing the experience acquired from the process of promoting the cluster, the demand survey of the companies and existing studies. The proposed roles of the government include (1) the establishment and adjustment of the related national strategies, (2) demand creation through a pilot project, (3) support for base elements such as technology development and establishment of standards, (4) education on and promotion of public goods and (5) introduction of leading utilization systems for the public sector. Private companies need to proceed with (1) discovering killer applications that can lead in the market, (2) formulating value innovation strategies for market creation, (3) promoting awareness of inter-enterprise collaboration for the development of convergence technologies and (4) promoting active investment strategies for robot demand companies.

In a related move, the government must carefully investigate which success factors contribute to the development and integration of industries in the regional cluster in which the robot industry is being fostered, and what problems are implicated. In addition, the performance of regional industry clusters must be constantly measured by means of various types of clusters, and such models must be furtherer expanded. In addition, the private sector must also conduct research and development, and formulate various forms of collaboration that can stimulate the promotion of the industry, along with efforts to cope with strategic situation variations for the expansion of the market. It is suggested that the continued efforts of the government and non-government organizations serve as the best catalysts of the spread of the robot industry.

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